Advancing Nanoscale Quantum Sensing in Quantum-Photonic Hybrid Solid-State Devices

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Quantum sensing with solid-state spins offers a powerful approach for achieving highly sensitive measurements of magnetic and electric fields, temperature, and pressure, as well as for probing quantum many-body interactions at the nanoscale. This approach leverages the unique properties of atomic-scale defects—such as nitrogen- and tin-vacancy centers in diamonds, rare-earth ions in crystals, and optically addressable spins in two-dimensional materials—to surpass the limitations of classical sensing. By employing error-robust control techniques tailored to specific sensing signals and sensor characteristics [1], solid-state quantum sensors can achieve ultrahigh sensitivity and superior spatial resolution [2]. In this talk, I will introduce recent advancements in nanoscale quantum sensing and its applications, including the engineering of high-density rare-earth ion ensembles for probing many-body interactions and preparing time-crystalline states [3], as well as the exploration of spin qubits for precision quantum sensing in two-dimensional van der Waals materials [4].

References

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